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JAP. ABSTRACTS E-1253 AUG 25 1992 VOL. 16 No.401 4-132491. JAP. ABSTRACTS E-998 NOV. 1990 VOL. 14 No.507 2-210923.

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UK CL (Edition K) H4L LDA LDSD LDSX
INT CL^5 H04B 7/26
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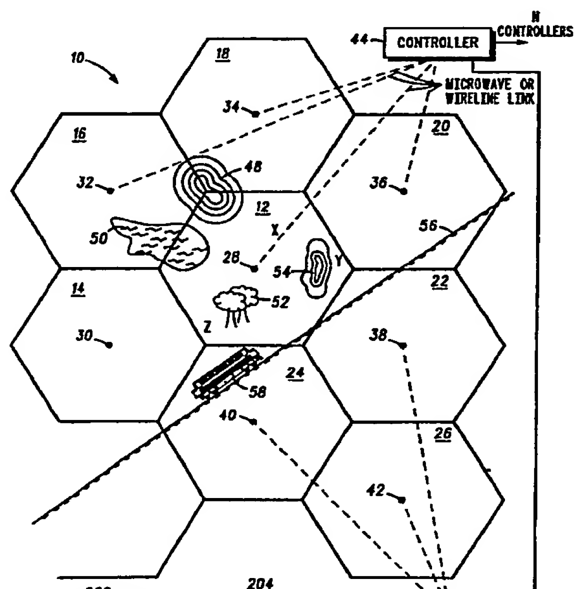
(54) A cellular communications system employing GPS positioning

(57) A communications system (10), providing communications coverage to at least one coverage area (12 - 26) comprises a plurality of mobile communications devices (68, 70) each having a GPS receiver (80, 82, 84) for receiving information (88, 90) from a Global Positioning System (86) relating each mobile communications device to a geographic position (x, y, z), and a transceiver (72, 74) for transmitting the position to a base station (28 - 42). A controller (44, 46) administers, through control of a base station, control of the communications system (10) in response to the position information.

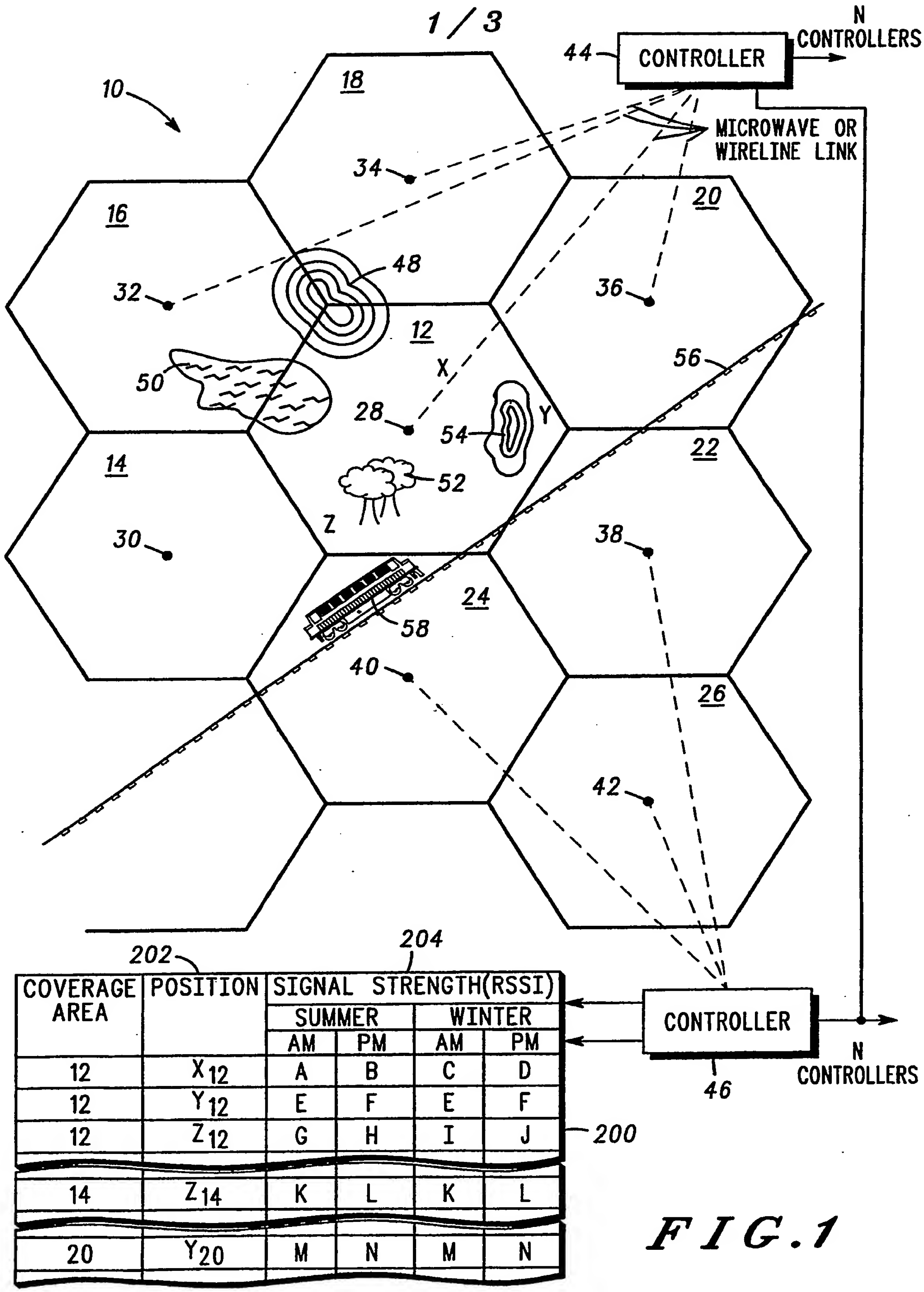


COVERAGE AREA	POSITION	SIGNAL STRENGTH(RSSI)			
		SUMMER		WINTER	
		AM	PM	AM	PM
12	X_{12}	A	B	C	D
12	Y_{12}	E	F	E	F
12	Z_{12}	G	H	I	J
14	Z_{14}	K	L	K	L
20	Y_{20}	M	N	M	N

FIG.1

GB 2 271 486 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.



COVERAGE AREA	POSITION	SIGNAL STRENGTH(RSSI)			
		SUMMER		WINTER	
		AM	PM	AM	PM
12	X_{12}	A	B	C	D
12	Y_{12}	E	F	E	F
12	Z_{12}	G	H	I	J
14	Z_{14}	K	L	K	L
20	Y_{20}	M	N	M	N

FIG.1

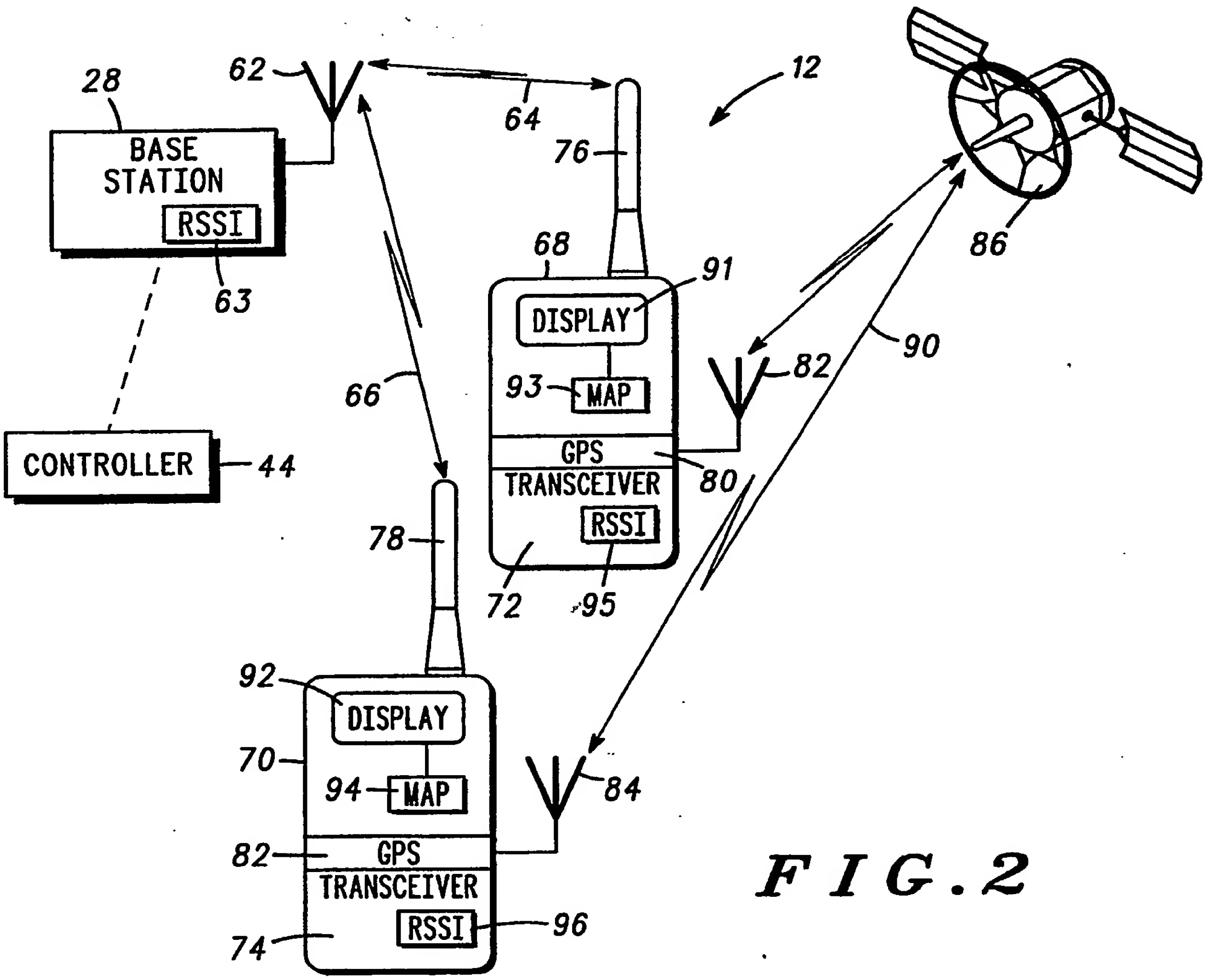

28
BASE STATION
RSSI
63
62
64
76
12
86
68
91
DISPLAY
93
MAP
82
90
66
GPS
TRANSCEIVER
80
RSSI
CONTROLLER
44
78
72
95
92
DISPLAY
70
94
MAP
84
82
GPS
TRANSCEIVER
74
RSSI
96

FIG. 2

FIG.3

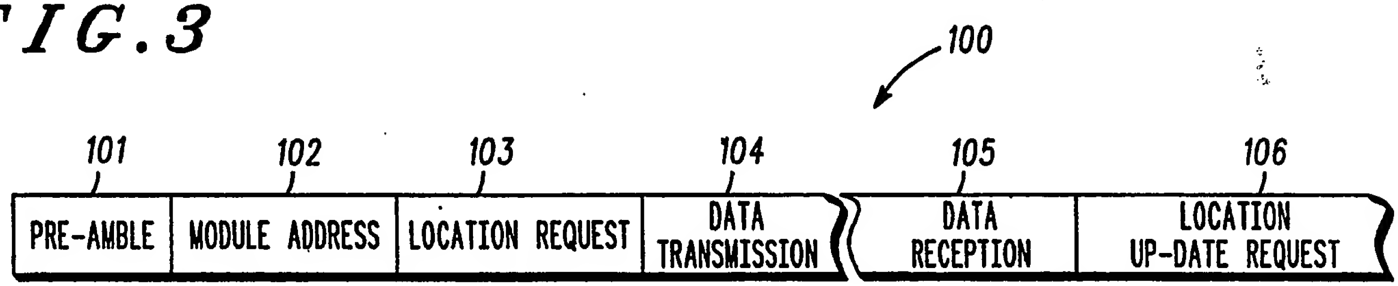
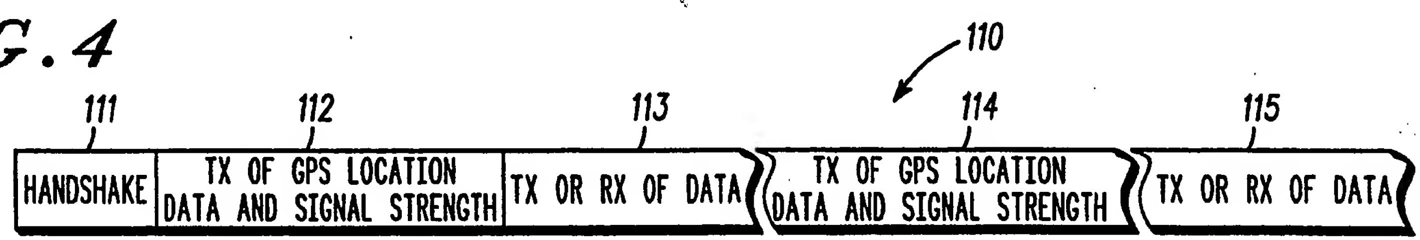

100
101
102
103
104
105
106
PRE-AMBLE
MODULE ADDRESS
LOCATION REQUEST
DATA TRANSMISSION
DATA RECEPTION
LOCATION UP-DATE REQUEST

FIG.4


110
111
112
113
114
115
HANDSHAKE
TX OF GPS LOCATION DATA AND SIGNAL STRENGTH
TX OR RX OF DATA
TX OF GPS LOCATION DATA AND SIGNAL STRENGTH
TX OR RX OF DATA

2271486

A Communications System.

Background to the Invention.

This invention relates, in general, to management of a communications system, such as a cellular communications system, and is particularly applicable to a communications system using information derived from a Global Positioning by Satellite System (GPS) for wide area control thereof.

Summary of the Prior Art.

The advent and implementation of a Global Positioning System (GPS) is known in the art. Primarily, GPS is used to provide accurate timing signals to terrestrial based units or to provide an accurate position for such a unit relative to the Earth. At present, the prohibitive factor preventing wide application of GPS is cost. However, GPS is already used for pin-pointing the location of yachts, for example, and further applications are being developed, such as in the field of vehicle location, as costs are reduced.

Current wide area terrestrial communications systems, such as the GSM cellular system in Europe, have complicated and elaborate operating protocols in order that the communications system may successfully 'hand-off' mobile units between different cells thereof. Moreover, the GSM 'hand-off' protocol is considered to be 'State-of-the-Art' in terrestrial wide area systems requiring cell transfers transparent to a mobile (subscriber) unit of the system. At present, all system management decisions in such a communications system are based on signal strength and/or signal quality information. The latter may comprise Bit Error Rate (BER) measurements for example. For clarity, the phrase "signal strength" will be used throughout this application to indicate signal strength and/or signal quality. Unfortunately, such a methodology is unable to compensate for surrounding signal aberrations caused by geographic environments or the speed and direction (vector) of the

mobile unit. Consequentially, 'hand-off' errors occasionally result therein.

It can be appreciated that there is a requirement within the art for a wide area terrestrial communications system which is devoid of the inherent pitfalls associated with incorrect 'hand-off' decisions. Moreover, it is desirable that such a wide area communications system has an adaptive capability, whereby overall system management is improved by compensation for surrounding operating environments affecting operational performance of a mobile unit therein.

Summary of the Invention.

This invention addresses at least some of the deficiencies described in the prior art above. In accordance with the present invention, there is provided a communications system providing communications coverage to at least one coverage area. The communications system has a controller for control of the system and a base station for communicating with a plurality of mobile communications devices. The base station is coupled to the controller for relaying messages to the controller and for receiving and relaying control information from the controller.
The plurality of mobile communications devices each have a GPS receiver for receiving information from a Global Positioning System relating each mobile communications device to a geographic position, and a transceiver for transmitting messages to the base station and for receiving control information from the base station. A transmitted message includes information relating to the geographic position and the controller administers, through control of a base station, control of the communications system in response to geographic position information transmitted by the mobile communications devices.

In the preferred embodiment, each device of said plurality of mobile communications devices further comprises a received signal strength indicator circuit for determining a signal strength of a received message, transmitted from the base station, at a particular

geographic position. The message transmitted to the base station from the mobile communications device further includes information regarding the determined signal strength, wherein the controller controls the system in response to both the geographic position and the received signal strength information transmitted by a mobile communications device. In addition, the controller further comprises a memory for storing correlation information compiled from received geographic position and associated received signal strength information corresponding therewith, and comparison means for comparing a received signal strength transmitted by a first mobile communications device, for a specific geographic position in a first coverage area, with other received signal strength information, retained in the memory, for that same geographic position as previously measures by a second mobile communications device from transmissions of said control information emanating from a base station in any adjacent coverage area. The controller administers control of the first communications device at least partially in response to the comparison. Moreover, the correlation information further contains information relating to environmental conditions whereby control of the communications system by the controller is further subject to any effect caused by variations of the environmental conditions on the received signal strength information for that specific geographic position. The correlation information further contains information relating to communication system usage during periods of a day, whereby control of the communications system by the controller is further subject to any affect caused by variations in system usage, for the particular period of the day, on the received signal strength information for that specific geographic position. Furthermore, the controller controls hand-off decisions, for said plurality of mobile communications devices, between base stations in adjacent coverage areas at least partially in response to the geographic position information.

In accordance with the preferred embodiment of the present invention, the base station further administers control, when required, of a subset of said plurality of communications devices located in any adjacent coverage area. Additionally, the controller

further comprises first determining means for determining usage of a first plurality of frequency channels, administered by a first base station in a first coverage area, by a first plurality of mobile communications devices and usage of a second plurality of frequency channels, administered by a second base station in any adjacent coverage area, by a second plurality of mobile communications devices. In the event that substantially all of said first plurality of available frequency channels are used in the first coverage area and substantially fewer of the second plurality of frequency channels are used in the adjacent coverage area, then the controller hands-off control of one or more of said first plurality of mobile communications devices from the first base station to the second base station thereby alleviating frequency congestion in the first coverage area. The base station further comprises transmitter power adjustment means for adjusting a power output of a transceiver thereof, wherein the output power of the base station is adjusted in response to at least the geographic position information received from the controller.

In the preferred embodiment, each of said plurality of mobile communications devices further comprises transmitter power adjustment means for adjusting a power output of a transceiver thereof. Output power of the mobile communications device is adjusted in response to at least the geographic position information received from the controller. The controller further comprises second determining means for determining usage of a first plurality of available frequency channels, administered by a first base station, in a first coverage area and usage of a second plurality of available frequency channels, administered by a second base station, in any adjacent coverage area. In the event that substantially all of said first plurality of available frequency channels are used in the first coverage area and substantially fewer of said second plurality of frequency channels are used in the adjacent coverage area, then the controller re-allocates administration of unused frequency channels from the second base station to the first base station thereby alleviating frequency congestion in the first coverage area. Moreover, the base station further comprises tracking means for

beam steering an antenna of the transceiver. The controller controls beam steering of the antenna in response to geographic position information transmitted by one of said plurality of mobile communications devices and thereby substantially optimises transmission of control information to one of said plurality of mobile communications devices and reception of messages from said one of said plurality of mobile communications devices. Furthermore, the controller further comprises means for controlling operating characteristics of a given mobile communications device. The controller, in response to geographic information received from one of said plurality of mobile communication devices, re-configures said operating characteristics of that mobile communications device in the communications system.

In the preferred embodiment, the communication system further comprises a billing centre, responsive to said plurality of said mobile communication devices and the controller. The billing centre has a timer for timing a duration of a billable call associated with a mobile communication device and administered by the controller and computation means for computing a fee for the call based on the duration of the call and a geographic position from which the call was made. In the preferred embodiment the communication system is a cellular system.

In a further aspect of the present invention, a controller, for controlling communication between a plurality of mobile communications devices in at least one coverage area in a communication system, comprises a transceiver for transmitting system control information to said plurality of mobile communications devices and for receiving geographic position information transmitted by said plurality of mobile communications devices. and computation means for analysing the geographic position information and for administering control of the communications system (10) in response thereto. Further, the geographic position information is derived from a (GPS) global positioning system. Additionally, the transceiver is receptive to received signal strength information determined and transmitted by one of said plurality of mobile communications devices located at a

particular geographic position. The computation means administers control of the communications system in response to both that particular geographic position and the received signal strength information. The controller further comprises a memory for storing correlation information compiled from received geographic position and associated received signal strength information corresponding therewith. The computation means further comprises comparison means for comparing a received signal strength transmitted by a first mobile communications device, for a specific geographic position in a first coverage area, with other received signal strength information, retained in the memory, for that same geographic position as previously measured by a second mobile communications device from transmissions of control information from a base station in any adjacent coverage area. The controller administers control of said first mobile communications device at least partially in response to the comparison. In this alternative aspect, the correlation information further contains information relating to environmental conditions, whereby control of the communications system is further subject to any effect caused by variations of the environmental conditions on the received signal strength information for that specific geographic position. In addition, the correlation information further contains information relating to communication system usage during periods of a day, whereby control of the communications system is further subject to any affect caused by variations in system usage, for the particular period of the day, on the received signal strength information for that specific geographic position. In the preferred embodiment, the controller is coupled to at least one base station whereby the controller controls communication between said plurality of mobile communications devices through control of the base station, and the controller controls hand-off decisions, for said plurality of mobile communications devices between base stations in adjacent coverage areas, at least partially in response to the geographic position information.

In this further aspect of the invention, the controller further comprises first determining means for determining usage of a first

plurality of frequency channels, administered by a first base station in a first coverage area, by a first plurality of mobile communications devices and usage of a second plurality of frequency channels, administered by a second base station in any adjacent coverage area, by a second plurality of mobile communications devices. In the event that substantially all of the first plurality of available frequency channels are used in the first coverage area and substantially fewer of the second plurality of frequency channels are used in the adjacent coverage area, then the controller (44, 46) hands-off control of one or more of the first plurality of mobile communications devices from the first base station to the second base station thereby alleviating frequency congestion in the first coverage area. In addition, the base station further comprises transmitter power adjustment means for adjusting a power output of a transceiver thereof, wherein the controller controllably adjusts output power of the base station in response to at least the geographic position information received from the controller. Furthermore, the controller further comprises second determining means for determining usage of a first plurality of available frequency channels, administered by a first base station, in a first coverage area and usage of a second plurality of available frequency channels, administered by a second base station, in any adjacent coverage area. In the event that substantially all of said first plurality of available frequency channels are used in said first coverage area and substantially fewer of said second plurality of frequency channels are used in said adjacent coverage area, then the controller (44, 46) re-allocates administration of unused frequency channels from said second base station to said first base station thereby alleviating frequency congestion in said first coverage area.

In this further aspect, the base station further comprises tracking means for beam steering an antenna thereof, whereby the controller controls beam steering of the antenna in response to geographic position information transmitted by one of said plurality of mobile communications devices and thereby substantially optimises transmission of control information to said one of said plurality of mobile communications devices and reception of

messages from said one of said plurality of mobile communications devices. Moreover, the controller further administers control, when required, of a subset of said plurality of mobile communications devices located in any adjacent coverage area. Additionally, the controller comprises means for controlling operating characteristics of a given mobile communications device, whereby the controller, in response to geographic information received from one of said plurality of mobile communication devices, re-configures operating characteristics of that mobile communications device in the communications system.

In a yet another aspect of the present invention, there is provided a method of operating a communications system covering at least one coverage area. The method comprising the steps of sending Global Positioning System (GPS) data to at least one mobile communications device located in said coverage area, receiving said GPS data at said at least one mobile communications device, relaying information, relating said at least one mobile communications device to a geographic position, to a controller that controls said communications system and analysing said geographic position information transmitted by the mobile communications devices. Subsequently, the controller determines a suitable control response and transmits, through control of a base station, the determined control response to said at least one mobile communication devices, thereby administering control of the communications system. Furthermore, a received signal strength is determined, at a particular geographic position, for a message transmitted to said at least one mobile communications device from said base station. The received signal strength information is then transmitted to the controller. The system is controlled in response to both said geographic position and said received signal strength information transmitted by the at least one mobile communications device.

In yet another aspect of the present invention, there is provided a mobile communications device comprising a GPS receiver for receiving information from a Global Positioning System relating the mobile communications device to a geographic position, a data base containing information defining functionality of the mobile

communications device in each of a plurality of defined coverage area and processing means for comparing the received geographic position with said information. The processing means controls the functionality of the mobile communications device, as defined in said data base, in response to the comparison of said geographic position with said plurality of defined coverage areas.

An exemplary embodiment of the present invention will now be described with reference to the accompanying drawings.

Brief Description of the Drawings.

Fig. 1, illustrates a preferred embodiment of a wide area communications system, and a management methodology therefor, in accordance with the present invention.

Fig. 2, illustrates a preferred embodiment of communications apparatus suitable for implementation in Fig. 1.

Fig. 3, illustrates a preferred embodiment of a base station telegram transmitted to a mobile unit of Fig. 2.

Fig. 4, illustrates a preferred embodiment of a telegram protocol of a mobile unit of Fig. 2.

Detailed Description of a Preferred Embodiment.

This invention proposes the application of GPS data to a wide area communications system for the system management thereof. In a preferred embodiment of the present invention, system management decisions are not only based on signal strengths of a two-way transmission path, but also on the vector (speed and direction) and location of a subscriber (mobile) unit within the system. With reference to Fig. 1, there is shown a preferred embodiment of a wide area terrestrial communications system in accordance with the present invention. In this illustration, the wide area terrestrial communications system is represented by a number

of hexagonal coverage areas (or cells), representative of a typical cellular radio communications system. Coverage areas 12-26 are arranged in a close packed configuration, wherein coverage area 12 is surrounded by six further coverage areas 14-24. A base station 28-42 is located at substantially the centre of each coverage area and controls and manages the operation of a mobile unit within a particular coverage area. The base stations 28-42 are coupled to controller 44, 46 which administer overall control of the wide area communications system. Furthermore, controllers 44 and 46 are coupled both to each other and N other identical controllers dispersed throughout the wide area communications system. It will be appreciated that the controllers 44, 46 are coupled to the base stations 28-42 by microwave or wire-line links or by some other alternative method obvious to one skilled in the art.

Coverage areas 12, 16 and 18 are bordered by a mountainous area 48. Furthermore, areas 12 and 16 share a common feature of a lake 50. In addition, coverage area 12 also contains a forest 52 and a mountainous ridge 54. Transport infrastructure, such as an ultra high speed railway system, is routed through adjacent coverage areas 24, 12, 22 and 20. A high speed train, capable of speeds of ~500 km/hr, passes along this railway.

With reference to Fig. 2, a preferred embodiment of communications apparatus suitable for operation in coverage area 12 is illustrated. It will be appreciated that coverage areas 14-26 each comprise a similar configuration to coverage area 12 and that coverage area 12 is given by way of example only. The base station 28 of coverage area 12 is coupled to controller 44 as previously discussed. Base station 12 comprises a transceiver 62 for transmitting and receiving signals 64, 66 to and from mobile units 68 and 70, respectively, and a received signal strength indicator circuit (RSSI) 63 for measuring the signal strength of a received signal. Mobile units 68, 70 typically comprise a transceiver 72, 74, and an antenna 76, 78 responsive to the transmitted signals 64, 66. The transceivers 72, 74 are coupled to the base station 28 through a radio communications link 64, 66 provided by the antennae 76, 78. Mobile units 68, 70 further comprise a user display 91, 92 and,

optionally, a digital map converter 93, 94 coupled thereto. The mobile units 68, 70 contain a received signal strength indicator (RSSI) circuit 95, 96 for determining the received signal strength of signal 64, 66 transmitted from the base station 28. It will be appreciated by one skilled in the art that although the communications system of Fig. 2 illustrates a cellular communications system having mobile transceiver therein, the invention is equally applicable to other forms of wide area communications systems, such as trunked radio systems, conventional two-way radio (PMR) systems, requiring system management control thereof. The mobile units 68, 70 further comprise an integrated GPS receiver coupled to a suitable antenna 82, 84. Location information, periodically derived from GPS satellite transmissions (86, 88, 89), is used by the mobile units 68, 70 to infer speed and direction, i.e. vector information. The digital map converter 93, 94 converts geographic information supplied by the satellite 86 to a visual format suitable for viewing on the display 91, 92 and indicating, graphically, the position of a user. It will be appreciated that the digital map converter 93, 94 may be, alternatively, located in the base station 12 and, as a consequence thereof, digital map information could be translated into a suitable format at the base station and transmitted to the mobile unit over a down-link.

With reference to Fig. 3, there is shown a preferred embodiment of a signalling telegram 100 transmitted from a base station to a mobile unit of the wide area communications systems of Fig. 1. The telegram 100 comprises a preamble 101, an address of a mobile unit 102, a location request 103 aimed at the addressed unit, time segments for data transmission 104 and reception 105 and a location up-date request 106. The preamble, as is well understood, typically comprises identification and synchronisation patterns for identifying the system and for synchronising the addressed mobile unit.

With reference to Fig. 4, a preferred embodiment for a mobile unit telegram protocol is illustrated. Subsequent to the decoding of the pre-amble 101 and mobile address 102 transmitted from the

base station, or the initialisation of a call instigated from the mobile unit (as will be understood), the mobile unit initiates a 'handshake' routine 111 with the base station. Eventually, the mobile responds to the location request 103 by transmitting GPS data, identifying its position within the wide area communications system, and signal strength information, obtained by the monitoring of prior transmissions to the mobile. The mobile unit then transmits or receives data 113. At the end of either data transmission or reception 113, or in response to a request from the base station, the mobile re-transmits its location 103, as obtained from the GPS receiver, and re-transmits signal strength information 114. The mobile is then in a state ready to receive to transmit further data 115 or to terminate communication.

Typically, GPS data is transmitted in a methodology transparent to a user through the application of concurrent voice and data capabilities, obvious to one skilled in the art and implemented in systems such as a CDMA, FDMA or a TDMA digital communication systems. Furthermore, a communications system with an intelligent infrastructure may be used to initiate transmission of GPS data from the mobile only when such data is required, thereby permitting improved data transmission facilities in the system.

The regular transmission of GPS data from the mobile units to a controller, via a base station, is used to compile a precise data base of system coverage. An exemplary embodiment of a data base 200 in accordance with the present invention is shown in Fig. 1. Since the data base may be continually updated by data from mobile units, a coverage profile with respect to time can be compiled. Such a coverage profile has particular applications to future communication system, such as a Personal Communications Network (PCN), which will operate at higher frequencies (e.g. 1800MHz) than present systems (800-900MHz) , such as GSM. It will be appreciated by one skilled in the art that higher frequency systems are more sensitive to propagation variations due to seasonal or even daily changes in environmental conditions.

Typically, the data base 200 contains position information 202 relative to a particular base station 28-42 within a specific coverage area 12-26, and signal strength information 204 associated therewith. Additionally, the data base 200 is continually improved by the continual storage of new position 202 and signal strength 204 information associated therewith. For example, position x may have a signal strength "a", as measured by a mobile unit from a transmission from the base station located at the centre of coverage area 12 during the peak morning periods in the summer months, whilst the signal strength may increase to "b" in the afternoon during the summer. During the winter, the signal strength may change, for example, to signal strengths "c" and "d" for the morning and afternoon respectively. In a similar way, position y, located behind the mountainous ridge 54, in coverage area 12, may have signal strengths, as recorded from a transmission from the base station located at the centre of coverage area 12, of "e" and "f" for the peak morning period and the afternoon period, respectively, during both the summer and winter months. Furthermore, position z, located behind forest 52, may have differing signal strengths "g", "h", "i", and "j" according to seasonal and daily variations and as determined from the signal strength of a signal emanating from the base station located at the centre of coverage area 12. Alternatively, position y may have signal strengths "k" and "l" as recorded from a transmission from the base station located at the centre of coverage area 20 for the peak morning period and the afternoon period, respectively, during both the summer and winter months. Moreover, signal strengths "k" and "l" could be greater than the respective signal strengths "e" and "f", thereby justifying a 'hand-off' decision between coverage areas 12 and 20. In a similar manner, the signal strengths "m" and "n" of position z, as measured from a transmission from the base station at the centre of cell 14, may be greater than the signal strengths for corresponding times as determined from a signal emanating from coverage area 12. Again, if "m" and "n" are greater than "e" and "f" a 'hand-off' decision would be justified.

It can be appreciated that the data base so compiled would clearly identify regions within each coverage area 12-26 which suffered from poor coverage, such as positions y and z and mountainous area 48, arising from low signal strengths and incorrect system control decisions. Such information could subsequently be used for future system planning and development. Moreover, 'hand-off' areas could be precisely defined in terms of a geographic position. In addition, system control decisions, such as 'hand-off', could also be made subject to seasonal and daily variations, e.g. foliage changes, environmental changes, traffic conditions or climatic changes. Furthermore, it will be appreciated that the size of the data base could be reduced if the RSSI data for a particular location was replaced by polynomial functions, for example, representing weighting factor for particular transmission paths, i.e. transmission paths recorded from different base station. The GPS position data received by the controller would then be weighted with these factors and subsequent comparisons made therebetween in order to determine whether a hand-off decision was warranted.

With regard to 'hand-off' decisions, the data base 200 would highlight opportunities for better system management. More specifically, if a particular coverage area (cell) is congested with mobile units, control of some of these mobiles may be directed to an adjacent cell capable of handling the additional responsibility thereof. Clearly, cell loading decisions can be administered with greater efficiency when position, signal strength and vector information are taken into account. In addition, frequency management of the communications system can be improved by using knowledge of mobile (subscriber) positions and vectors within the communications system. More specifically, the use of information inferred by GPS data permits dynamic frequency re-use to be managed in a more efficient and effective manner than is currently possible with signal strength information alone. Available unused frequencies in a particular cell may be dynamically re-assigned to an adjacent cell suffering problems associated with a congestion of mobile units, thereby improving spectrum efficiency of the communications system at any particular instant in time.

Furthermore, since the communications system is able to identify a current operating location of a mobile unit, a base station, currently administering control thereover, can dynamically adjust either its power output to the mobile unit in question or request that the mobile increase its power output, and thereby further increase the flexibility of the communications system. Moreover, if a base station were to malfunction, mobile failures would be readily apparent and adjacent cells could increase their output power levels and/or adapt their antenna beam shapes in an attempt to provide the area effected by the base station malfunction with a satisfactory and temporary coverage. It will be appreciated that this feature would be particularly desirable when a beam-steered antenna system is used by a base station.

With particular regard to antenna beam-steered cell-site techniques, problems associated with dynamic beam steering are greatly reduced with the application of the preferred embodiment of the present invention thereto. At present, beam-steering decisions are liable to errors analogous to those presently associated with 'hand-off' errors i.e. signal strength aberrations resulting from geographic location. Precise knowledge of a mobile (subscriber) location and vector (speed and direction) permits mitigation of beam-steering decision errors resulting from propagation distortion. For example, a base station may receive signals from a mobile (subscriber) via multiple paths due to signal reflections and distortions arising from the operating environment. In these circumstances, the lack of independent position information may therefore cause incorrect beam-steering. A further aspect of the present invention may apply derived vector (speed and direction) information to pre-set channel equalisers or other devices that mitigate the effect of multiple transmission paths.

A further application of the preferred embodiment of the present invention is the use of GPS data for geographic (feature access) control. For example, a mobile unit (subscriber) may be permitted access to certain predetermined operating features of the communications system in a given geographic area. Alternatively, the mobile unit (subscriber) may have restricted communication

system access in a particular geographic area. Moreover, a mobile unit (subscriber) may be billed for services on a geographic basis, e.g. calls made in the Greater London area may incur a greater cost per unit than those made in the Yorkshire Dales. For example, the duration of a call and GPS position information would be brought together at a billing centre, at which point a suitable tariff would be calculated for the call. Moreover, the billing centre which could be co-located with the controller 44, 64. Furthermore, mobile units (subscribers) of a secure (encrypted) radio system may be provided with the opportunity to zero or change user (subscriber) encryption keys on a geographic basis, which offers an important enhancement of existing secure system management facilities. More specifically, if a mobile unit (subscriber radio) is removed from a geographic area, a base station could zero or change the encryption key thereof and thereby disable the subscriber radio.

In a similar manner, a mobile unit moving from one geographic area to another may be programmed to automatically change channels, signalling and other parameters/user features, such as keypad functionality, display presentation and receiver scan configuration, i.e. re-configuration of the functionality of the mobile unit, thereby providing fully automatic interoperability with local communication systems. This feature is particularly relevant to public safety radio systems. It will of course be appreciated that either a base station or a controller could instruct a mobile unit to re-configure its operating characterisitc subject to GPS derived geographic position. Alternatively, a mobile unit could re-configure itself. More specifically, the mobile unit would contain a pre-programmed geographic coverage map that indicated, for example, system configuartion and mobile unit access privileges for defined geographic areas. If the mobile unit roamed outside a defined geographic area, as determined by a present geographic location derived from the GPS system, the mobile unit would automatically re-configure itself accordingly.

A benefit arising from the preferred embodiment of the present invention is that a system operating protocol thereof is substantially identical to existing communication system protocols.

Therefore, there is an inherent ability to integrate the preferred embodiment into an existing communications system without either adversely affecting the operation of the existing system or requiring that all mobiles in the existing system be up-graded immediately. Moreover, in the event of GPS failure, the similar operating characteristics of the proposed system and the existing system ensure that sufficient, albeit inferior, communications system management would be maintained.

It will be appreciated that an invention so designed and described produces the novel advantages of a wide area communications system having the desirable attributes of an overall improvement in system management and, specifically, 'hand-off' decisions made therein. More particularly, such an invention provides adaptive frequency use within coverage areas of the system and the ability to adapt and control power levels in base stations and mobiles thereof in response to system requirements. In addition, the communications system can compensate for daily and seasonal variations in propagation. Furthermore, the preferred embodiment of the present invention provides a base station antenna steering methodology capable of improving system efficiency.

Claims.

1. A communications system (10), providing communications coverage to at least one coverage area (12-26), having:

a) a controller (44, 46) for control of the system;

b) a base station (28-42), for communicating with a plurality of mobile communications devices (68, 70), coupled to said controller (44, 46) for relaying messages to the controller and for receiving and relaying control information from the controller; and

c) a plurality of mobile communications devices (68, 70), each having:

i) a GPS receiver (80, 82, 84) for receiving information (88, 90) from a Global Positioning System (86) relating each mobile communications device to a geographic position (x, y, z); and

ii) a transceiver (72, 74) for transmitting messages to the base station (28-42) and for receiving control information from the base station;

wherein a transmitted message (112) includes information relating to said geographic position (x, y, z) and the controller (44, 46) administers, through control of a base station, control of the communications system (10) in response to geographic position information transmitted by the mobile communications devices.

2. A communications system (10) in accordance with claim 1, wherein each device of said plurality of mobile communications devices (68, 70) further comprises:

a received signal strength indicator circuit (95, 96) for determining a signal strength of a received message, transmitted from said base station, at a particular geographic position;

and the message transmitted to the base station (112) from the mobile communications device (68, 70) further includes information regarding said determined signal strength, wherein the controller (44, 46) controls the system in response to both said geographic position and said received signal strength information transmitted by a mobile communications device.

3. A communications system (10) in accordance with claim 2, wherein the controller (44, 46) further comprises:

a memory (200) for storing correlation information compiled from received geographic position and associated received signal strength information corresponding therewith; and

comparison means for comparing a received signal strength transmitted by a first mobile communications device, for a specific geographic position in a first coverage area, with other received signal strength information, retained in said memory (200), for that same geographic position as previously measured by a second mobile communications device from transmissions of said control information emanating from a base station in any adjacent coverage area;

wherein the controller administers control of said first mobile communications device at least partially in response to said comparison.

4. A communications system (10) in accordance with claim 3, wherein the correlation information further contains information relating to environmental conditions (204), whereby control of the communications system by the controller is further subject to any effect caused by variations of said environmental conditions (204) on said received signal strength information for that specific geographic position.

5. A communications system (10) in accordance with claim 3 or 4, wherein the correlation information further contains information relating to communication system usage during periods of a day, whereby control of the communications system is further subject to any affect caused by variations in system usage, for said particular period of the day, on said received signal strength information for that specific geographic position.

6. A communications system (10) in accordance with any preceding claim, wherein the base station further administers control, when required, of a subset of said plurality of mobile communications devices located in any adjacent coverage area.

7. A communications system (10) in accordance with any preceding claim, wherein the controller controls hand-off decisions, for said plurality of mobile communications devices, between base stations in adjacent coverage areas at least partially in response to said geographic position information.

8. A communications system (10) in accordance with any preceding claim, wherein the controller (44, 46) further comprises first determining means for determining usage of a first plurality of frequency channels, administered by a first base station in a first coverage area, by a first plurality of mobile communications devices and usage of a second plurality of frequency channels, administered by a second base station in any adjacent coverage area, by a second plurality of mobile communications devices, whereby in the event that substantially all of said first plurality of available frequency channels are used in said first coverage area and substantially fewer of said second plurality of frequency channels are used in said adjacent coverage area, then the controller (44, 46) hands-off control of one or more of said first plurality of mobile communications devices from said first base station to said second base station thereby alleviating frequency congestion in said first coverage area.

9. A communications system (10) in accordance with any preceding claim, wherein the base station further comprises transmitter power adjustment means for adjusting a power output of a transceiver (62) thereof, wherein the output power of the base station is adjusted in response to at least said geographic position information received from the controller (44, 46).

10. A communications system (10) in accordance with any preceding claim, wherein each of said plurality of mobile communications devices (68, 70) further comprises transmitter power adjustment means for adjusting a power output of a transceiver (72, 74) thereof, wherein the output power of the mobile communications device is adjusted in response to at least said geographic position information received from the controller (44, 46).

11. A communications system (10) in accordance with any preceding claim, wherein the controller (44, 46) further comprises second determining means for determining usage of a first plurality of available frequency channels, administered by a first base station, in a first coverage area and usage of a second plurality of available frequency channels, administered by a second base station, in any adjacent coverage area, whereby in the event that substantially all of said first plurality of available frequency channels are used in said first coverage area and substantially fewer of said second plurality of frequency channels are used in said adjacent coverage area, then the controller (44, 46) re-allocates administration of unused frequency channels from said second base station to said first base station thereby alleviating frequency congestion in said first coverage area.

12. A communications system (10) in accordance with any preceding claim, wherein the base station further comprises tracking means for beam steering an antenna of said transceiver (72, 74), whereby the controller controls beam steering of the antenna in response to geographic position information transmitted by one of said plurality of mobile communications devices and thereby substantially optimises transmission of control information to one of said plurality of mobile communications devices and reception of messages from said one of said plurality of mobile communications devices.

13. A communications system (10) in accordance with any preceding claim, wherein the controller further comprises means for controlling operating characteristics of a given mobile communications device, whereby the controller (44, 46), in response to geographic information received from one of said plurality of mobile communication devices, re-configures said operating characteristics of that mobile communications device in the communications system.

14. A communications system (10) in accordance with any preceding claim, wherein the communication system further comprises a billing centre, responsive to said plurality of said mobile communication devices and said controller, having:

a timer for timing a duration of a billable call associated with a mobile communication device and administered by the controller; and

computation means for computing a fee for said call based on the duration of the call and a geographic position from which the call was made.

15. A communications system (10) in accordance with any preceding claim, wherein the communication system is cellular system.

16. A controller (44, 46) for controlling communication between a plurality of mobile communications devices in at least one coverage area in a communication system, comprising:

a transceiver for transmitting system control information to said plurality of mobile communications devices and for receiving geographic position information transmitted by said plurality of mobile communications devices; and

computation means for analysing said geographic position information and for administering control of the communications system (10) in response thereto.

17. A controller (44, 46) in accordance with claim 15, wherein the geographic position information is derived from a (GPS) global positioning system.

18. A controller (44, 46) in accordance with claim 16 or 17, wherein the transceiver is receptive to received signal strength information determined and transmitted by one of said plurality of mobile communications devices located at a particular geographic position, wherein said computation means administers control of the communications system (10) in response to both that particular geographic position and said received signal strength information.

19. A controller (44, 46) in accordance with claim 18, wherein the controller (44, 46) further comprises:

a memory (200) for storing correlation information compiled from received geographic position and associated received signal strength information corresponding therewith; and

said computation means further comprises:

comparison means for comparing a received signal strength transmitted by a first mobile communications device, for a specific geographic position in a first coverage area, with other received signal strength information, retained in said memory (200), for that same geographic position as previously monitored by a second mobile communications device from transmissions of control information from a base station in any adjacent coverage area;

wherein the controller administers control of said first mobile communications device at least partially in response to said comparison.

20. A controller (44, 46) in accordance with claim 19, wherein the correlation information further contains information relating to climatic conditions (204), whereby control of the communciations system by the controller is further subject to any effect caused by variations of said climatic conditions (204) on said received signal strength information for that specific geographic position.

21. A controller (44, 46) in accordance with claim 19 or 20, wherein the correlation information further contains information relating to communication system usage during periods of a day, whereby control of the communications system by the controller is further subject to any affect caused by variations in system usage, for said particular period of the day, on said received signal strength information for that specific geographic position.

22. A controller (44, 46) in accordance with any one of claims 16 to 21, wherein said controller is coupled to at least one base station whereby said controller controls communication between said plurality of mobile communications devices through control of said base station, and said controller controls hand-off decisions, for said plurality of mobile communications devices between base stations in adjacent coverage areas, at least partially in response to said geographic position information.

23. A controller (44, 46) in accordance with claim 22, further comprising first determining means for determining usage of a first plurality of frequency channels, administered by a first base station in a first coverage area, by a first plurality of mobile communications devices and usage of a second plurality of frequency channels, administered by a second base station in any adjacent coverage area, by a second plurality of mobile communications devices, whereby in the event that substantially all of said first plurality of available frequency channels are used in said first coverage area and substantially fewer of said second plurality of frequency channels are used in said adjacent coverage area, then the controller (44, 46) hands-off control of one or more of said first plurality of mobile communications devices from said first base station to said second base station thereby alleviating frequency congestion in said first coverage area.

24. A controller (44, 46) in accordance with any one of claims 22 or 23, wherein the base station further comprises transmitter power adjustment means for adjusting a power output of a transceiver (62) thereof, wherein the controller controllably adjusts output power of the base station in response to at least said geographic position information received from the controller (44, 46).

25. A controller (44, 46) in accordance with any one of claims 22 to 24, further comprising second determining means for determining usage of a first plurality of available frequency channels, administered by a first base station, in a first coverage area and usage of a second plurality of available frequency channels, administered by a second base station, in any adjacent coverage area, whereby in the event that substantially all of said first plurality of available frequency channels are used in said first coverage area and substantially fewer of said second plurality of frequency channels are used in said adjacent coverage area, then the controller (44, 46) re-allocates administration of unused frequency channels from said second base station to said first base station thereby alleviating frequency congestion in said first coverage area.

26. A controller (44, 46) in accordance with any one of claims 22 to 25, wherein the base station further comprises tracking means for beam steering an antenna thereof, whereby the controller controls beam steering of the antenna in response to geographic position information transmitted by one of said plurality of mobile communications devices and thereby substantially optimises transmission of control information to said one of said plurality of mobile communications devices and reception of messages from said one of said plurality of mobile communications devices.

27. A controller (44, 46) in accordance with any one of claims 16 to 26, wherein the controller further administers control, when required, of a subset of said plurality of mobile communications devices located in any adjacent coverage area.

28. A controller in accordance with any one of claims 16 to 27, further comprising means for controlling operating characteristics of a given mobile communications device, whereby the controller (44, 46), in response to geographic information received from one of said plurality of mobile communication devices, re-configures said operating characteristics of that mobile communications device in the communications system.

29. A method of operating a communications system (10) that covers at least one coverage area, the method comprising the steps of:

a) sending Global Positioning System (GPS) data to at least one mobile communications device located in said coverage area;

b) receiving said GPS data at said at least one mobile communications device;

c) relaying information (88, 90), relating said at least one mobile communications device to a geographic position (x, y, z), to a controller that controls said communications system;

d) analysing said geographic position information transmitted by the mobile communications devices, thereby determining a suitable control response for the controller;

e) transmitting, through control of a base station, said determined control response to said at least one mobile communication devices, thereby administering control of the communications system (10).

30. A method of operating a communications system (10) in accordance with claim 29, further comprising the steps of:

a) determining a received signal strength, at a particular geographic position; for a message transmitted to said at least one mobile communications device from said base station;

b) transmitting, to the controller, information relating to said received signal strength;

c) controlling the system in response to both said geographic position and said received signal strength information transmitted by said at least one mobile communications device.

31. A mobile communications device (68, 70) comprising:

a) a GPS receiver (80, 82, 84) for receiving information (88, 90) from a Global Positioning System (86) relating the mobile communications device to a geographic position (x, y, z);

b) a data base containing information defining functionality of the mobile communications device in each of a plurality of defined coverage area; and

c) processing means for:

i) comparing said received geographic position with said information; and

ii) controlling the functionality of the mobile communications device, as defined in said data base, in response to the comparison of said geographic position (x, y, z) with said plurality of defined coverage areas.

32. A controller for a communications system (10) substantially as described herein and with reference to Figs. 1 to 4 of the accompanying drawings.

33. A mobile communications device (68, 70) substantially as described herein and with reference to Fig. 2 of the accompanying drawings.

34. A method of operating a communications system (10) substantially as described herein and with reference to Figs. 1 to 4 of the accompanying drawings.

35. A communications system (10) substantially as described herein and with reference to Figs. 1 to 4 of the accompanying drawings.

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Relevant Technical fields

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Databases (see over)

(i) UK Patent Office

(ii) ONLINE DATABASE: WPI, INSPEC

Date of Search

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Documents considered relevant following a search in respect of claims 1-35

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	JAP. ABSTRACTS E-1253 August 25 1992 volume 16 number 401 4-132491	1,16,29, 31 at least
X,Y	JAP. ABSTRACTS E-998 November 6 1990 volume 14 number 507 2-210923	1,16,29, 31 at least

SF2(p) MS - doc99\fil000341

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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